

1           **DETECTING COUNTERFEITING USING CUSTOM COLORED INKS**

2           **FIELD OF THE INVENTION**

3           This application is directed to the fields of digital  
4           imaging and counterfeit deterrence. It is more specifically  
5           concerned with the printing of identifying marks on a hard  
6           copy using custom color inks, and the subsequent detection  
7           or non-detection of those identifying marks in a digitized  
8           image of the hard copy.

9           **BACKGROUND OF THE INVENTION**

10          It is a constant endeavor to find improved techniques for  
11          placing visible identifying marks onto printed material that  
12          are difficult or impossible to reproduce using common  
13          desktop scanners and printers, and even by many three and  
14          four color industrial printing processes. The marks are  
15          placed at specified locations on the hard copy and have  
16          visibly significant sizes. The areas covered by the marks  
17          are called *areas of coverage*. The ability to detect the  
18          presence of those identifying marks in a scanned and  
19          digitized image of the printed material is generally useful  
20          in establishing authenticity of the scanned object. More  
21          importantly, the detected absence or alteration of the color  
22          of the identifying marks is an immediate indication of a  
23          possibly counterfeit copy.

1 With the present easy availability of image scanners and  
2 color printers that produce relatively good quality replicas  
3 of hard copy documents, the risk of what is called "casual  
4 counterfeiting," that is, counterfeiting done by novices,  
5 has greatly increased. It would be advantageous to have an  
6 inexpensive and effective deterrent to casual and other  
7 counterfeiting.

#### 8 **SUMMARY OF THE INVENTION**

9 Thus, the present invention provides an effective deterrent  
10 to casual counterfeiting. In one aspect, a method of  
11 achieving the deterrent exploits the limited color gamut of  
12 commonly available printers by using selected inks having  
13 colors that are out-of-gamut colors for those printers.

14 Another aspect of the present invention provides for  
15 achieving the deterrent by sorting a plurality of candidate  
16 documents into a first group of scanned documents not having  
17 the out-of-gamut color, and into a second group of scanned  
18 documents having the out-of-gamut color, so that the scanned  
19 documents in the first group being probably counterfeit, and  
20 the scanned documents in the second group being possibly  
21 authentic.

22 An example of a method implementing the present invention  
23 includes the steps of: providing a plurality of authentic  
24 hard-copy documents, each of the authentic hard-copy  
25 documents including at least one mark having at least one  
26 color that is out of gamut of a printing device having at  
27 least three colors; color scanning a plurality of candidate  
28 documents to form a two-dimensional array of image pixels

1 for each candidate document; searching each array for the at  
2 least one color; sorting the plurality of candidate  
3 documents into a first group of scanned documents not having  
4 the at least one color, and into a second group of scanned  
5 documents having the at least one color, so that the scanned  
6 documents in the first group being probably counterfeit, and  
7 the scanned documents in the second group being possibly  
8 authentic.

9 **BRIEF DESCRIPTION OF THE DRAWINGS**

10 These and other aspects, features, and advantages of the  
11 present invention will become apparent upon further  
12 consideration of the following detailed description of the  
13 invention when read in conjunction with the drawing figures,  
14 in which:

15 Fig. 1 shows an  $a^*-b^*$  chrominance plane for  $L^*=70$ ;

16 Fig. 2 shows an  $a^*-b^*$  chrominance plane for  $L^*=45$ ;

17 Fig. 3 illustrates a color selection in the differential  
18 gamut that can be produced using custom colored inks but can  
19 not be produced by any combination of inks available to the  
20 example printer;

21 Fig. 4 shows example spectral distributions of three typical  
22 color filters that could be used, one in front of each of  
23 the three image sensors, to produce a colorimeter; and

24 Fig. 5 shows an example embodiment of the present invention.

1     **DESCRIPTION OF THE INVENTION**

2     The present invention provides methods, systems and  
3     apparatus for effective deterrent to casual and other  
4     counterfeiting. With the present easy availability of image  
5     scanners and color printers that produce relatively good  
6     quality replicas of hard copy documents, the risk of what is  
7     called "casual counterfeiting," that is, counterfeiting done  
8     by novices, has greatly increased. In an example embodiment  
9     of a method of achieving the deterrent is to exploit the  
10    limited color gamut of commonly available printers by using  
11    selected inks having colors that are out-of-gamut colors for  
12    those printers. In this way, even though a scanner may  
13    accurately capture the out-of-gamut colors, it will not be  
14    possible for the commonly available printer to accurately  
15    reproduce the colors. The absence of the correct colors in  
16    the counterfeit printed copy can be detected.

17   As used herein, a *digital image* is an abstraction of a  
18   physical image that has been scanned and stored in a  
19   computer's memory as rectangular arrays of numbers  
20   corresponding to that image's (one or more) color planes.  
21   Each array element corresponds to a very small area of the  
22   physical image and is called a picture element, or *pixel*.  
23   The numeric value associated with each pixel for a  
24   monochrome image represents the magnitude of its average  
25   brightness of its single color (for example, black and  
26   white) plane. For a color image, each pixel of the digital  
27   image has associated values representing the magnitudes of  
28   average brightness of its at least three color components  
29   represented in three or more color planes. The color

1 components are associated with spectrally dispersed primary  
2 colors used to represent a broad range of colors in the  
3 visible color spectrum, and the values of the at least three  
4 color components are the relative brightness of the three  
5 primaries used to represent a particular color.

6 If the digital image has been converted from continuous tone  
7 picture elements to halftone picture elements, the halftone  
8 picture elements will be referred to herein as *pels* and  
9 their color component values referred to as *ink-density*  
10 *values*. As with pixels, a different value is associated  
11 with each different one of the image's color planes for each  
12 pel, and the number of color planes in the halftoned  
13 representation may be greater than the number of color  
14 planes in the digital image. Thus, the digital image and  
15 the hard copy printed from the halftoned image are two  
16 distinct, but related, representations of the same physical  
17 image.

18 Herein the word *halftoned* will be taken to mean that  
19 gradations from light to dark are obtained by the relative  
20 darkness and density of tiny dots of inks that are to be  
21 applied to paper or other substrate material. Also, if the  
22 digital image is a color image, its pixel values are  
23 ordinarily the relative brightness values of additive  
24 radiant primary colors, such as those of a computer's  
25 display. Therefore, the halftone conversion process as  
26 referred to herein also includes conversion of the pixel  
27 values of radiant primary colors into the pel values of  
28 light absorbing primary colors (such as Cyan, Magenta,  
29 Yellow and Black ink densities) that are needed for  
30 printing. The halftoned image then may be printed on paper  
31 or other substrate material; such printed image is herein

1 called a *hard copy*.

2 Whenever reference is made herein to color planes, it is  
3 understood to include any number of color planes used by a  
4 particular image's digitizing technique to define the  
5 pixel's or pel's color characteristics. Pixel values, as  
6 well as pel values, have a magnitude represented by at least  
7 one binary digit or bit.

8 Whenever reference is made herein to *ink density* or  
9 *ink-density value*, it is understood to refer to any  
10 substance that is used to apply color to paper or other  
11 substrate material, be that substance ink, dye, toner or  
12 other. Further, ink-density values range from 0% to 100%,  
13 meaning from no ink applied to the area of a picture element  
14 on paper up to total coverage of the area on paper.

15 Specific colors are definable by specific values of their  
16 color components. Although it is possible mathematically to  
17 define pixel or pel color component values that are greater  
18 than 100% or less than 0%, such specific colors are not  
19 physically realizable. The three dimensional volumes that  
20 contain all possible combinations of picture element color  
21 component values are called *gamuts*. Only those colors lying  
22 on the surface of or within the volume of a gamut can be  
23 created from the given set of primary colors that define the  
24 gamut. The colors that can physically exist but can not be  
25 realized by any combination of the primary colors defining a  
26 gamut are called *physically-realizable out-of-gamut* colors.  
27 The explicit use of out-of-gamut colors is the essence of  
28 the present invention.

29 To further explain the meaning and utility of out-of-gamut

1 colors, the international standard color representation CIE  
2 1976 ( $L^*a^*b^*$ ), herein referred to as CIELab, will be used.  
3 This color representation standard is described in Wyszecki,  
4 G and Stiles, W.S., *Color Science: Concepts and Methods,*  
5 *Quantitative Data and Formulae*, Second Edition, John Wiley &  
6 Sons, NY, 1982, which is herein included by reference.

7 All colors in the spectrum of physical colors can be  
8 represented by a their coordinates in a three dimensional  
9 color space. The three dimensions herein will be called a  
10 *triplet*. The CIELab coordinates, namely  $L^*$ ,  $a^*$  and  $b^*$ , used  
11 herein, are color triplets in a perceptual color space. By  
12 this, it is meant that moving an equal distance from a first  
13 triplet in any direction to another triplet will be  
14 perceived by a human viewer as an approximately equal change  
15 in perceived color. Thus, the distances moved from a first  
16 triplet by a *just noticeable difference* in color will be  
17 approximately equal, and the locus of all colors of just  
18 noticeable color differences will roughly lie on a sphere  
19 surrounding the first triplet. The coordinate  $L^*$  ranges  
20 from 0 to 100. The triplet [100,0,0] represents the  
21 coordinates of a reference white. For hard copy, the  
22 reference white is taken to be the measured values of the  
23 substrate with no applied inks under a specified  
24 illuminating source. The triplet [0,0,0] represents black,  
25 a color of unmeasurably small luminance.

26 Changes in the perceived luminance of a color will  
27 correspond to changes of only the coordinate  $L^*$ , and changes  
28 of chrominance that produce an equally perceived luminance  
29 will involve changes of only the coordinates  $a^*$  and  $b^*$ .  
30 Thus, it is informative to view the  $a^*-b^*$  chrominance planes  
31 in which  $L^*$  is a constant.

1 Referring to Figure 1 and Figure 2, the chrominance plane is  
2 shown for  $L^*=70$  and  $L^*=45$ , respectively. The three nested  
3 areas shown represent the gamut of physically-realizable  
4 colors (101) and (201), , the gamut of *object colors* (103)  
5 and (203) and the gamut of *printable colors* (105) and (205).  
6 Not all combinations of  $a^*$  and  $b^*$  represent physically  
7 realizable colors. Only those combinations that lie within  
8 the areas (101) and (201) are physically realizable. Object  
9 colors are colors that arise by the reflection of a  
10 reference illumination source from an object, which in our  
11 case is paper with applied inks. The gamut of object colors  
12 is considerably smaller than that of physically realizable  
13 colors. Physically realizable colors do not have to depend  
14 on reflected light and can therefore be made up of any  
15 number of radiating sources, as opposed to the single  
16 reflected reference source for object colors. Still smaller  
17 is the gamut of printable colors, which represents all  
18 colors (of course, having the same  $L^*$ ) that can be  
19 reproduced by any combination of the primary color inks used  
20 in the printing process. The area outside the printable  
21 colors gamut but inside the object colors gamut is the area  
22 of interest for the present invention. Colors lying in this  
23 in-between area are those that can be reflected from custom  
24 color inks applied to paper.

25 It should be apparent that if the planes of constant  $L^*$  are  
26 stacked one on another in numerical order from  $L^*=0$  to  
27  $L^*=100$ , three dimensional volumes will be produced. The  
28 three-dimensional gamut of printable colors lies entirely  
29 within or touching the three-dimensional object color gamut  
30 which, in turn, lies totally within or touching the  
31 three-dimensional gamut of physically realizable colors. As



1 with the differential area of the two-dimensional  $a^*-b^*$   
2 plane, the *differential gamut* volume lying outside the  
3 printable colors gamut volume but inside the object colors  
4 gamut volume is the volume of interest for then present  
5 invention. Figure 3 illustrates a color selection, a deep  
6 green (307), in the differential gamut that can be produced  
7 using custom colored inks but can not be produced by any  
8 combination of inks available to the example printer. It  
9 lies outside the gamut of *printable colors* (305) but inside  
10 both the gamut of *object colors* (303) and the gamut of  
11 physically-realizable colors (301). The gamuts of most three  
12 color or four color printers are very similar in shape and  
13 size and those printers can only print approximate  
14 representations of the out-of-gamut colors that lie within  
15 the differential volume.

16 An example embodiment of the present invention is in the  
17 apparatus used for scanning and sorting of bank checks  
18 and/or other transaction documents, at very high speed. In  
19 this embodiment, detection of included out-of-gamut colors  
20 on bank checks is done by a rudimental colorimeter. A  
21 typical rudimental colorimeter is embodied by using three  
22 image scanning elements that are optically focused on the  
23 illuminated stream of paper checks. Each scanning element is  
24 covered by a different colored spectral filter. Figure 4  
25 shows example spectral distributions of three typical color  
26 filters, a red appearing filter (401), a green appearing  
27 filter (403), and a blue appearing filter (405), that could  
28 be used, one in front of each of the three image sensors.  
29 Establishing and calibrating ratios of the scanned values of  
30 the three scanning elements, when focused on an identical  
31 area of the bank check, allows the average color of that  
32 area to be measured.

1 In an example embodiment, referring to Figure 5, the  
2 illuminated bank check stream is scanned by the colorimeter  
3 (501). If the presence of the correct out-of-gamut color is  
4 not confirmed by scanned color values from the image scan  
5 (503), the document is rejected as a possible counterfeit  
6 (505). Conversely, if the specific out-of-gamut color is  
7 detected, within a specified color tolerance, the document  
8 can be classified as probably authentic (507), pending other  
9 checks of authenticity that are not dependent on color  
10 discrimination, such as the shape or placement of the  
11 out-of-gamut colored object in the document image. If all  
12 bank checks have been scanned (509), the process is  
13 finished; otherwise steps (501) through (509) are repeated.

14 It will be clear to those skilled in the art that other  
15 modifications to the disclosed embodiments can be effected  
16 without departing from the spirit and scope of the  
17 invention. For example, a colorimeter can be embodied using  
18 a single scanning element with a segmented three-color  
19 filter placed near its object focal plane. The described  
20 embodiments ought to be construed to be merely illustrative  
21 of some of the more prominent features and applications of  
22 the invention. Other beneficial results can be realized by  
23 applying the disclosed invention in a different manner or  
24 modifying the invention in ways known to those familiar with  
25 the art.

26 Thus the present invention includes a method includes the  
27 steps of: providing at least one hard-copy document, each  
28 authentic hard-copy document including at least one mark  
29 having at least one color that is out of gamut of a printing  
30 device having at least three colors; color scanning a

1 plurality of candidate documents in forming a  
2 two-dimensional array of image pixels for each candidate  
3 document; searching each array for the at least one color;  
4 and sorting the plurality of candidate documents into a  
5 first group of scanned documents not having the at least one  
6 color, and into a second group of scanned documents having  
7 the at least one color, so that the scanned documents in the  
8 first group being probably counterfeit, and the scanned  
9 documents in the second group being possibly authentic.

10 In some embodiments of the method each of the pixels has at  
11 least three color pixel values; and/or the step of color  
12 scanning includes employing a colorimeter; and/or the step  
13 of providing includes printing using a custom-color ink;  
14 and/or the step of providing authentic hard-copy documents  
15 includes providing a plurality of bank checks; and/or  
16 further comprises the steps of noting correct pixel  
17 locations of the at least one color in the authentic  
18 document; determining particular pixel locations of the  
19 color in each of the second group of scanned documents, and  
20 forming a third group of scanned documents not having the  
21 particular pixel locations corresponding to the correct  
22 pixel locations, and into a fourth group of scanned  
23 documents having the particular pixel locations  
24 corresponding to the correct pixel locations, so that the  
25 scanned documents in the third group being probably  
26 counterfeit, and the scanned documents in the fourth group  
27 being possibly authentic.

1 In further embodiments of a method of the present invention,  
2 the method comprises the steps of employing an  
3 authentication test taken from a group of authentication  
4 tests including: size correspondence; location  
5 correspondence; magnetic number correspondence; checking  
6 account pattern-of-use exception; unexpected presence of  
7 ultraviolet fluorescing; unexpected presence of  
8 thermochromic responding; unexpected presence of laser  
9 resonating inks; unexpected absence of ultraviolet  
10 fluorescing; unexpected absence of thermochromic responding;  
11 unexpected absence of laser resonating inks; and any  
12 combination of these or other authentication tests.

13 For example, checking account pattern-of-use exception  
14 tests, include, but are not limited to: unexpectedly large  
15 gap in check sequence numbers; duplicate check sequence  
16 numbers; check sequence number electronically unreadable;  
17 new payee inconsistent with previous check writing pattern;  
18 unusually large amount of check; unusual deposit of check  
19 into a foreign bank account; and any combination of these or  
20 other fraud detection tests.

1 The present invention also includes a method for imparting a  
2 plurality of marks onto a hard copy using at least one  
3 custom colored ink, and subsequent evaluation of a scanned  
4 and digitized image of the hard copy for the purpose of  
5 counterfeit detection, including the steps of: providing a  
6 hard copy; imparting onto the hard copy at least one visible  
7 mark using at least one chosen colored ink, each the marks  
8 covering an area of coverage on the hard copy and each area  
9 of coverage having defined position within the hard copy;  
10 scanning the hard copy to form a digitized image having at  
11 least three image planes, each the image plane being  
12 represented by an array having pixel brightness data for a  
13 plurality of pixels, each of the pixels having at least  
14 three color component and having a pixel position; examining  
15 the pixels of the digitized image corresponding to the at  
16 least one the area of coverage; and determining the presence  
17 or absence of the expected color in the at least one area of  
18 coverage based on the values of the color components of  
19 pixels corresponding to and lying within the area of  
20 coverage. In some cases, the scanned and digitized image is  
21 a business transaction document.

22 Variations described for the present invention can be  
23 realized in any combination desirable for each particular  
24 application. Thus particular limitations, and/or embodiment  
25 enhancements described herein, which may have particular  
26 advantages to the particular application need not be used  
27 for all applications. Also, not all limitations need be  
28 implemented in methods, systems and/or apparatus including  
29 one or more concepts of the present invention.

30 The present invention can be realized in hardware, software,  
31 or a combination of hardware and software. A visualization

1 tool according to the present invention can be realized in a  
2 centralized fashion in one computer system, or in a  
3 distributed fashion where different elements are spread  
4 across several interconnected computer systems. Any kind of  
5 computer system - or other apparatus adapted for carrying  
6 out the methods and/or functions described herein - is  
7 suitable. A typical combination of hardware and software  
8 could be a general purpose computer system with a computer  
9 program that, when being loaded and executed, controls the  
10 computer system such that it carries out the methods  
11 described herein. The present invention can also be  
12 embedded in a computer program product, which comprises all  
13 the features enabling the implementation of the methods  
14 described herein, and which - when loaded in a computer  
15 system - is able to carry out these methods.

16 Computer program means or computer program in the present  
17 context include any expression, in any language, code or  
18 notation, of a set of instructions intended to cause a  
19 system having an information processing capability to  
20 perform a particular function either directly or after  
21 conversion to another language, code or notation, and/or  
22 reproduction in a different material form.

23 Thus the invention includes an article of manufacture which  
24 comprises a computer usable medium having computer readable  
25 program code means embodied therein for causing a function  
26 described above. The computer readable program code means  
27 in the article of manufacture comprises computer readable  
28 program code means for causing a computer to effect the  
29 steps of a method of this invention.

30 Similarly, the present invention may be implemented as a

1 computer program product comprising a computer usable medium  
2 having computer readable program code means embodied therein  
3 for causing a function described above. The computer  
4 readable program code means in the computer program product  
5 comprising computer readable program code means for causing  
6 a computer to effect one or more functions of this  
7 invention. Furthermore, the present invention may be  
8 implemented as a program storage device readable by machine,  
9 tangibly embodying a program of instructions executable by  
10 the machine to perform method steps for causing one or more  
11 functions of this invention.

12 It is noted that the foregoing has outlined some of the more  
13 pertinent objects and embodiments of the present invention.  
14 This invention may be used for many applications. Thus,  
15 although the description is made for particular arrangements  
16 and methods, the intent and concept of the invention is  
17 suitable and applicable to other arrangements and  
18 applications. It will be clear to those skilled in the art  
19 that modifications to the disclosed embodiments can be  
20 effected without departing from the spirit and scope of the  
21 invention. The described embodiments ought to be construed  
22 to be merely illustrative of some of the more prominent  
23 features and applications of the invention. Other  
24 beneficial results can be realized by applying the disclosed  
25 invention in a different manner or modifying the invention  
26 in ways known to those familiar with the art.